A giant bamboo rat from the latest Miocene of Yunnan

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Abstract The Shuitangba subbasin lignite deposits of the Zhaotong Basin in northern Yunnan Province have produced vertebrate fossils of terminal Miocene age. We conducted test wet screening of fossiliferous sediment in 2014 to increase representation of small mammals. This effort produced four teeth of a very large bamboo rat, much larger than the previously known bamboo rat present at Shuitangba, and representing a new species. This new species is characterized by its molars being remarkably larger than those of other known species of *Miorhizomys*, and being hypsodont with cementum, and less anterorposteriorly compressed. The age of this new species from Shuitangba is in the range of 6.2 to 6.7 Ma. It appears that diverse bamboo rats of the extinct genus *Miorhizomys* were present in the Late Miocene of Yunnan, somewhat before the 6 Ma appearance of extant *Rhizomys* to the north in the vicinity of Shanxi Province.

Key words Shuitangba, Yunnan, Late Miocene, small mammals, bamboo rat

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1 Introduction

Shuitangba is an open lignitic pit mine site in a small subbasin of the expansive Zhaotong Basin of northern Yunnan Province. Zhaotong Basin is well known for its rich deposits of Late Miocene terrestrial sediments with multiple lignite layers quarried for fuel. In addition to plant material the deposits are known to produce fossil vertebrates. The pit at Shuitangba has been exploited periodically for lignite, during which abundant vertebrate fossils, especially mammals, have been exposed. The Zhaotong Formation at Shuitangba is thinner than in the main body of Zhaotong Basin.

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Fossil mammals at Shuitangba are moderately diverse (for example, Dong et al., 2014, Ji et al., 2015). Hand excavation has produced exquisite fossils, but slow and careful digging leads to small collections, especially of the microfauna. Representation is also affected by taphonomic and collecting bias against retrieval of very small vertebrates. We have attempted to reduce such bias by systematic screening of large volumes of sediment for small mammals with some success (Flynn et al., 2019).

Additional screening initiated in 2014 in productive fossiliferous layers within the Shuitangba sequence, added to the list of small mammals reported in Jablonski et al. (2014). The results of that work will be developed elsewhere, but we report here the recovery of a new, surprisingly large species of bamboo rat that coexisted with a more common, smaller form at Shuitangba. While the presence of bamboo rats in the Late Miocene of South China has been documented (Flynn and Qi, 1982), and while two species co-occur today in parts of Southeast Asia, it was unexpected to find a species of bamboo rat at Shuitangba of such large size.

2 Material and methods

The specimens reported here are currently housed at the Zhaotong Institute of Cultural Relics Protection and Archaeology in the Zhaotong (ZT) catalogue system. They were retrieved by wet screening test samples from layers 9 to 11 of the Shuitangba section. The normally magnetized sediment correlates in age with chron C3An. At this time, it cannot be resolved whether the normal sediment represents C3An.1n or C3An.2n, so the age of the specimens falls in the broad window of 6.2 to 6.7 Ma on the Gradstein et al. (2012) time scale. Comparative materials include fossils from Lufeng, Yunnan Province, and from Yushe Basin, Shanxi Province, as well as casts of extant species from the zoological collection of the American Museum of Natural History, New York, USA (AMNH). Measurements in mm.

3 Systematic paleontology

Mammalia Linnaeus, 1758

Rodentia Bowdich, 1821

Spalacidae Gray, 1821

Rhizomyinae Winge, 1887

***Miorhizomys* Flynn, 2009**

***Miorhizomys gigas* sp. nov.**

Etymology *gigas*, Greek for giant.

Holotype ZT 2014-0266, right M1 (Fig. 1A).

Referred specimens ZT 2014-0170, left m3; ZT 2014-0392, left m2; ZT 2014-0470, right m1 (Fig. 1B–D).

Locality and age Shuitangba hominoid exposure, shell horizon in normally magnetized sediment of layers 9 to 11 of the local sequence and correlated with chron C3An, 6.2 to 6.7 Ma.

Fig. 1 Isolated molars of the large bamboo rat *Miorhizomys gigas* sp. nov., in occlusal view
A. holotype ZT 2014-0266, right M1; B. ZT 2014-0170, left m3, reversed image so that it appears as right; C. ZT 2014-0392, reversed left m2; D. ZT 2014-0470, right m1. Scale bar = 1 cm

Diagnosis Large rhizomyine rodent showing the molar crown features of *Miorhizomys* (molars not compressed anteroposteriorly as they are in living *Rhizomys* and *Cannomys*); molars hypsodont and with cementum; largest known species of the genus.

Description Four isolated teeth are attributed to this new species. The upper dentition is represented by the holotype ZT 2014-0266, right M1. This large tooth widens toward the roots, where its length × width = 6.3 ×7.1 mm. Maximum length (see Table 1) is greater, 6.8 mm, because the high crown is inclined posteriorly. The tooth is hypsodont (Fig. 2A), measuring 12.0 mm in height; the hypostria as preserved is 9.0 mm long. There are four major transverse lophs. The anteroloph and protoloph join the protocone; the mesoloph and metaloph-posteroloph complex join the hypocone. The anterior part of M1 is not as wide as the posterior moiety. M1 is convexly rounded without an anterolingual flexus. There is a narrow protocone-hypocone connection. The thin enamel of the posteroloph is chipped. This molar has three small roots.

Of the lower dentition, the first molar, ZT 2014-0470, is worn and broken anteriorly (posterior width, 4.75 mm). The metaconid joins the anterolophid, but not directly buccally toward the protoconid. The mesolophid, hypolophid and posterolophid are complete and parallel, and extend posterolingually. The left m2, ZT 2014-0392, is in early wear with height = 9.27 mm, hypostriid = 7.02 mm. Its crown widens toward the base. From the protoconid, the anterolophid-metalophid complex and the mesolophid extend lingually. The anterolophid-metalophid complex includes two small enamel lakes. Confluent with the base of the hypolophid, the hypoconid joins the protoconid narrowly. In this early wear stage, the posterior enamel lake is incomplete. The hypostriid is filled with cementum. There are two small posterior roots and a larger anterior root. The left m3, ZT 2014-0170 (l × w = 7.8 × 7.6 mm) expands posteriorly toward its base. Preserved crown height is 9.6 mm, its hypostriid about 8 mm long and bearing cementum. In early wear, the anterolophid-metalophid complex

Table 1 Dimensions (maxima) of isolated molars of *Miorhizomys gigas* sp. nov. in occlusal view (mm)

Specimen	Length	Width
M1, ZT 2014-0266, holotype	6.8	7.1
m1, broken, ZT 2014-0470	--	4.75
m2, ZT 2014-0392	7.1	7.0
m3, ZT 2014-0170	7.8	7.6

is proportionally larger than that of m2. The mesolophid is incomplete. The hypolophid is broadly connected to the protoconid, but has a narrow junction with the hypoconid. The oblique posterolophid is short and directed posterolingually.

Occlusal surfaces of molars are flattened by wear that approximates planes. Wear of the first lower molar was the most advanced, however, and was dominantly antero-posterior, with the occlusal surface worn as a shallow trough, deepest along the midline.

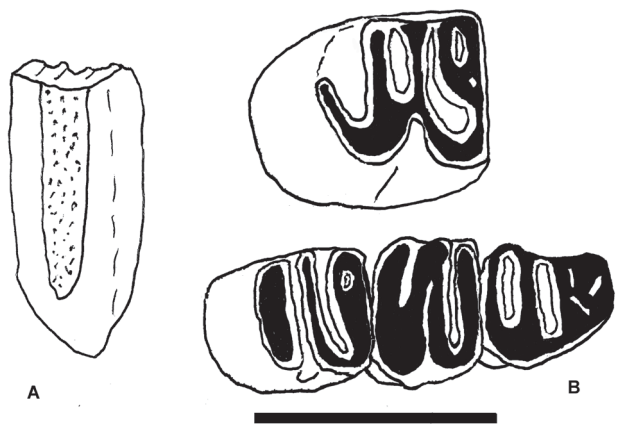

Fig. 2 Line drawing of molars of *Miorhizomys gigas* sp. nov. and *Rhizomys sinensis*
A. lingual view of holotype ZT 2014-0266, right M1 of *Miorhizomys gigas* sp. nov. Cementum fills the hypostria; B. comparison of *M. gigas* m2 ZT 2014-0392 with right mandibular tooth row of extant *Rhizomys sinensis* (AMNH 115527). Scale bar = 1 cm

4 Discussion

Large size and hypsodonty distinguish *Miorhizomys gigas* sp. nov., from other species of the genus. Full hypsodonty (Fig. 2A, molar height being the greatest dimension of unworn teeth) is an unusual condition for *Miorhizomys* (Flynn, 2009). Molars retain relatively small roots and major molar reentrants are buttressed by cementum, which is also unusual for the genus. *Miorhizomys gigas* is the largest species of its genus, larger than the Late Miocene Siwalik species *M. pilgrimi* (Table 1). *Miorhizomys gigas* is among the largest of known rhizomyines, even rivaling the Pliocene age *Anepsirhizomys opdykei* in size (Table 2 and Flynn 1982). The genus *Anepsirhizomys* had different, derived molar morphology: a deepened lingual reentrant nearly bisecting m2–3.

Miorhizomys gigas sp. nov., is the second of two bamboo rat species recognized at Shuitangba. The first, cf. *Miorhizonys tetracharax*, is smaller and is represented by several specimens. Its single known m2 shows greater width (when worn) than length: 4.1 × 4.6 mm (see Table 2). Cf. *Miorhizomys tetracharax* appears to be the same species as the common bamboo rat at the somewhat older Lufeng locality of Yunnan. The body mass of the latter was probably 1–2 kg.

The moist habitat of the Miocene Lufeng community of Yunnan supported a diverse mammalian fauna including multiple bamboo rat species. Flynn and Qi (1982) distinguished

three rhizomyines at Lufeng largely by size, and at that time considered them indistinguishable from Late Miocene species of the Siwaliks of Pakistan. These were the small *Miorhizomys nagrii*, *M. tetracharax*, and cf. *M. pilgrimi*. The latter was largest, a worn m2 measuring 4.7 × 5.0 mm (see Table 2). Presently the species level identification of all three Lufeng bamboo rats must be re-evaluated through comparison with other fossil rhizomyines. It seems reasonable to note that, regarding large size, the similar "cf. *M. pilgrimi*" of Lufeng represents a suitable predecessor of *Miorhizomys gigas* at Shuitangba.

Table 2 Size comparisons for select lower second molars of fossil bamboo rats, Tribe Rhizomyini (mm)

Species	Specimen	Length	Width
Miorhizomys gigas sp.nov.	ZT 2014-0392	7.1	7.0
Cf. *M. tetracharax*	ZT 2007-206	4.4	4.5
Cf. *M. tetracharax*	Lufeng	4.1	4.6
Cf. *M. pilgrimi*	Lufeng	4.7	5.0
Miorhizomys tetracharax	Siwalik average*	4.2	4.3
Cf. *M. pilgrimi*	Siwalik YGSP 8366*	5.3	4.6
Miorhizomys choristos	Siwalik YGSP 4053*	5.6	4.4
Anepsirhizomys opdykei	Siwalik DP 678*	6.7	5.3

Notes: YGSP, Yale Geological Survey of Pakistan; DP, Dartmouth Peshawar Siwalik research project; * source Flynn (1982).

Body size The body mass of the living bamboo rat of China, *Rhizomys sinensis*, averages about 2 kg, but individuals vary considerably. For fossils, relative dental size may be used to estimate body size, assuming a broadly constant relationship between molar size and body proportions. Correlations of molar size to body mass have relatively large prediction errors, so body mass estimates usually incorporate a measure of the wear surface area of the entire tooth row, or (for large rodents) the dimensions of the incisor (Millien and Bovy, 2010).

Given that *Miorhizomys gigas* sp. nov. is represented by only four cheek teeth (one broken), comparison of its m2 with a jaw of a living relative of known mass provides at least an approximation of body size. We compared the *M. gigas* m2 with the skull and mandible of *Rhizomys sinensis* (AMNH 115527), a living species of about 2 kg mass (Fig. 2B). *Miorhizomys gigas* was larger: occlusal width of the second lower molar of *M. gigas* when worn was somewhat greater, but its length was nearly 50% greater than that of *R. sinensis*. The mass of *M. gigas* would have been well over 2 kg. The only other Shuitangba rodent larger than the uncommon *M. gigas*, was the phylogenetically distinct beaver, so frequently encountered during excavation. The adult semi-aquatic beaver *Steneofiber zhaotungensis* had wider molars plus an expanded p4 as in all members of its family.

Comments on early *Rhizomys* The oldest known fossil *Rhizomys* is from the latest Miocene of the Yushe Basin, Shanxi Province (the origin of the sister genus *Cannomys* remains unknown). Yushe bamboo rats show features that are incompletely transformed toward modern *Rhizomys*, so while classified as *Rhizomys*, are subsumed by the subgenus *Brachyrhizomys* Teilhard de Chardin, 1942 (Flynn, 2009). The earliest Yushe record is *Rhizomys* (*Brachyrhizomys*) *shajius* from a Late Miocene site projected to fall high in chron

C3An.1n, so dated as 6.0 to 6.1 Ma (Flynn and Wu, 2017). It is small for a bamboo rat, but shows the reduced lower molar mesolophid that accompanies shortening of the tooth row in *Rhizomys*. While peripheral to the South China biogeographic region, the Yushe population was contemporary with or slightly younger than the Shuitangba bamboo rats. Conceivably, a species of *Miorhizomys* could be ancestral to *Rhizomys*, and while *Miorhizomys* diversity persisted in South China, the peripheral bamboo rats of Yushe in North China may have differentiated as *Rhizomys* (*Brachyrhizomys*). This scenario rests on few data, but is testable with more fossils.

5 Conclusion

The Late Miocene mammalian assemblage from Shuitangba in northeastern Yunnan had two species of bamboo rats, including the very large new species described here, *Miorhizomys gigas*. The large body size lineage to which *M. gigas* belongs may also include the large bamboo rat species recorded at the somewhat older Yunnan site of Lufeng. Living *Rhizomys* likely originated at about this time (6–7 Ma) and in a fauna roughly contemporary with Shuitangba but biogeographically separate. Concerning body mass, *M. gigas* was second in size in the Shuitangba rodent community only to the beaver *Steneofiber zhaotungensis*.

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云南晚中新世一巨型竹鼠

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摘要：云南昭通盆地水塘坝地点的褐煤沉积出产中新世末期脊椎动物化石。为增加小哺乳动物的样品，我们在2014年对出产化石的沉积物开展尝试性筛洗。通过筛洗，获得了四颗竹鼠的牙齿。这种竹鼠个体极大，远大于水塘坝已知的竹鼠，代表了一个新种。新种的臼

齿尺寸明显大于所有已知的*Miorhizomys*种类，臼齿高冠，齿沟内充填白垩质，不甚前后向压缩。新种在水塘坝的出现年代为6.2至6.7百万年前。这一发现显示，在约6百万年前的现生属*Rhizomys*在山西省北部地区出现之前，已绝灭的*Miorhizomys*就展现出了较高的多样性。

关键词：水塘坝，云南，晚中新世，小哺乳动物，竹鼠

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